June 1, 1943. W. T. POWELL 2,320,885

SIGNALING SYSTEM

Filed March 21, 1941 4 Sheets-Sheet 1

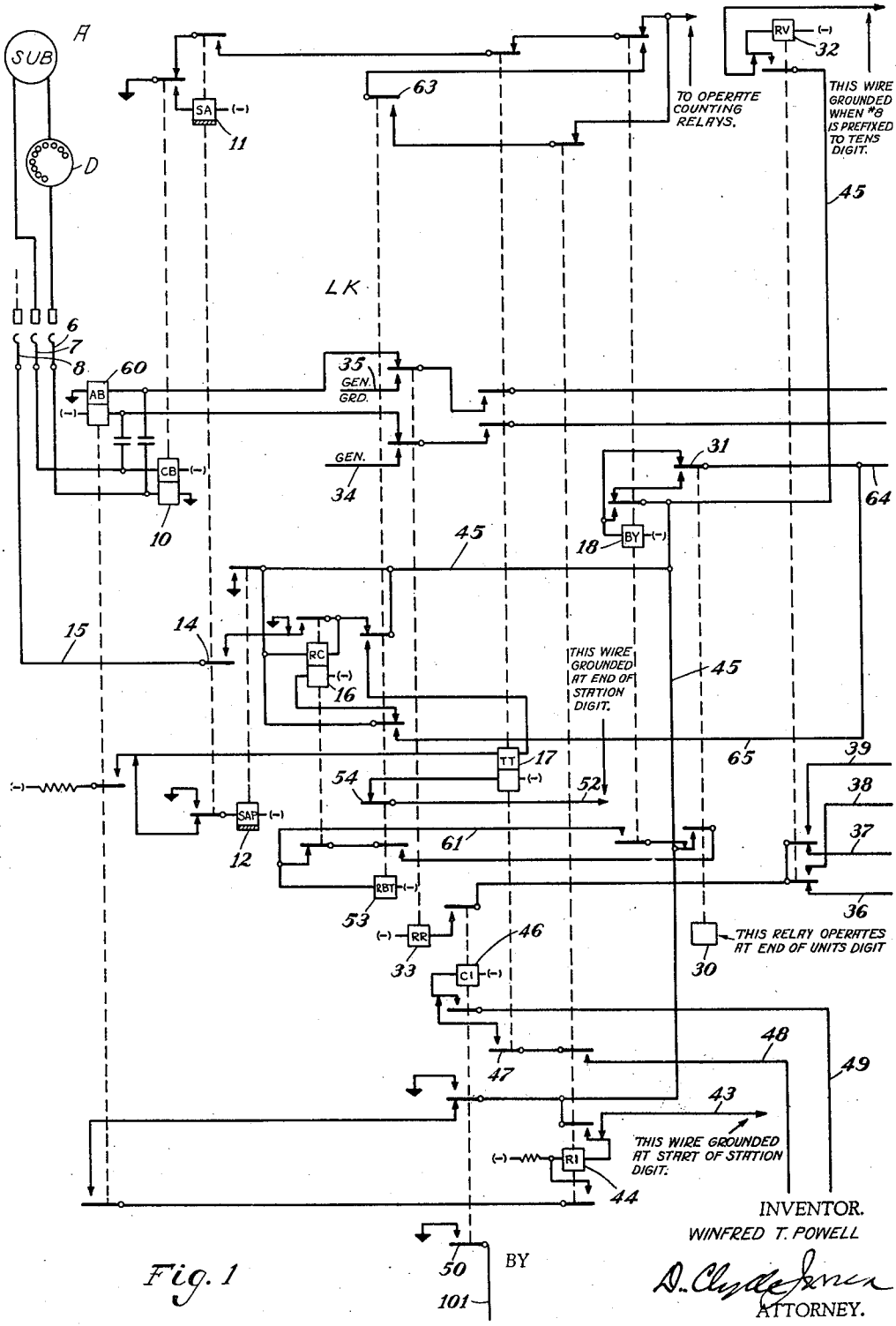


Fig. 1

INVENTOR.
WINFRED T. POWELL

BY

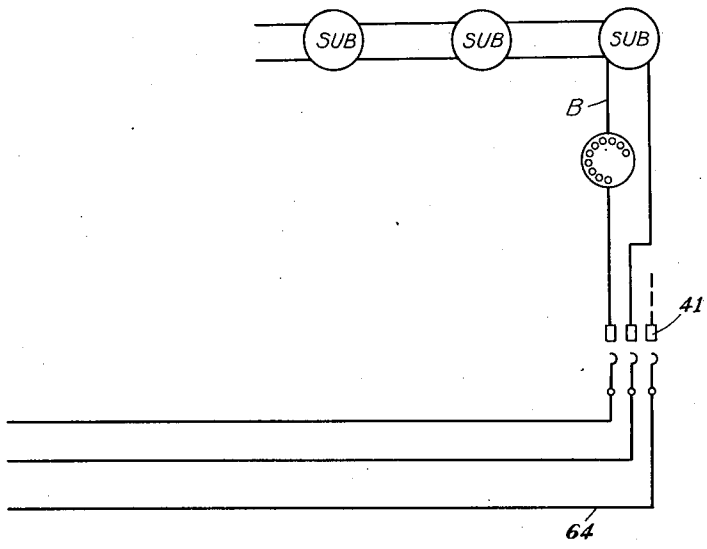
D. Clyde James

ATTORNEY.

June 1, 1943. W. T. POWELL 2,320,885

SIGNALING SYSTEM

Filed March 21, 1941 4 Sheets-Sheet 2



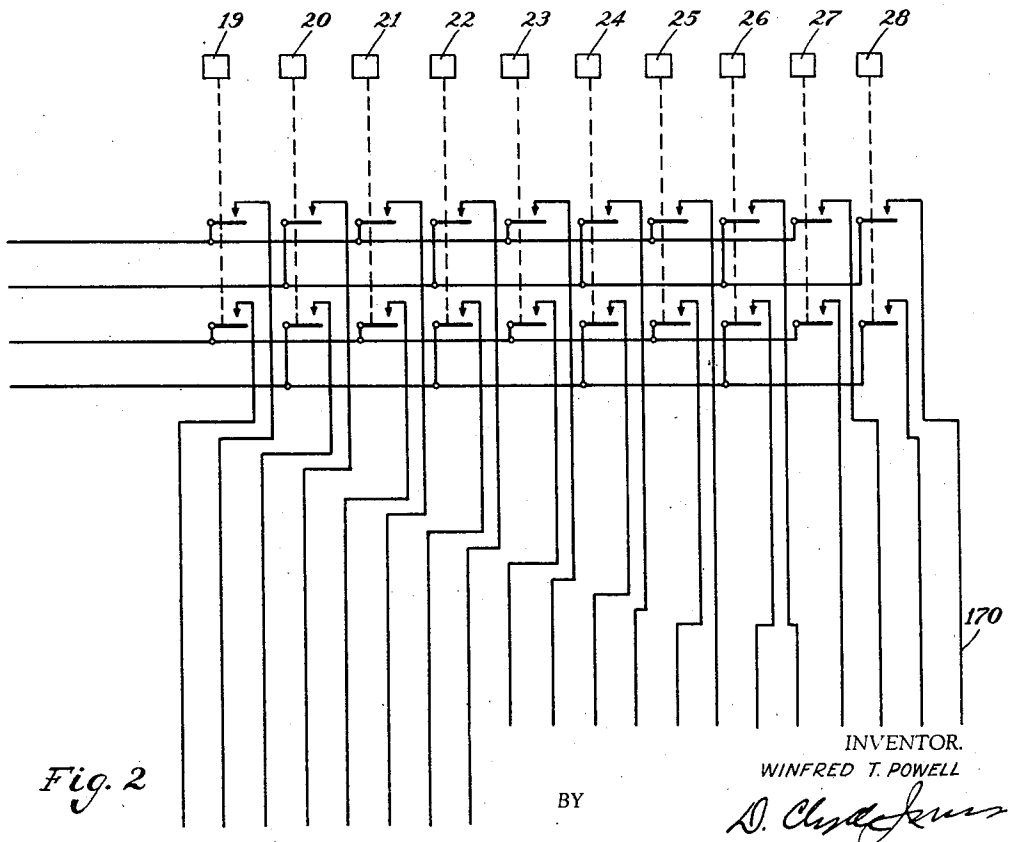


Fig. 2

INVENTOR.
WINFRED T. POWELL

BY D. Clyde Jones

ATTORNEY.

June 1, 1943. W. T. POWELL 2,320,885

SIGNALING SYSTEM

Filed March 21, 1941 4 Sheets-Sheet 3

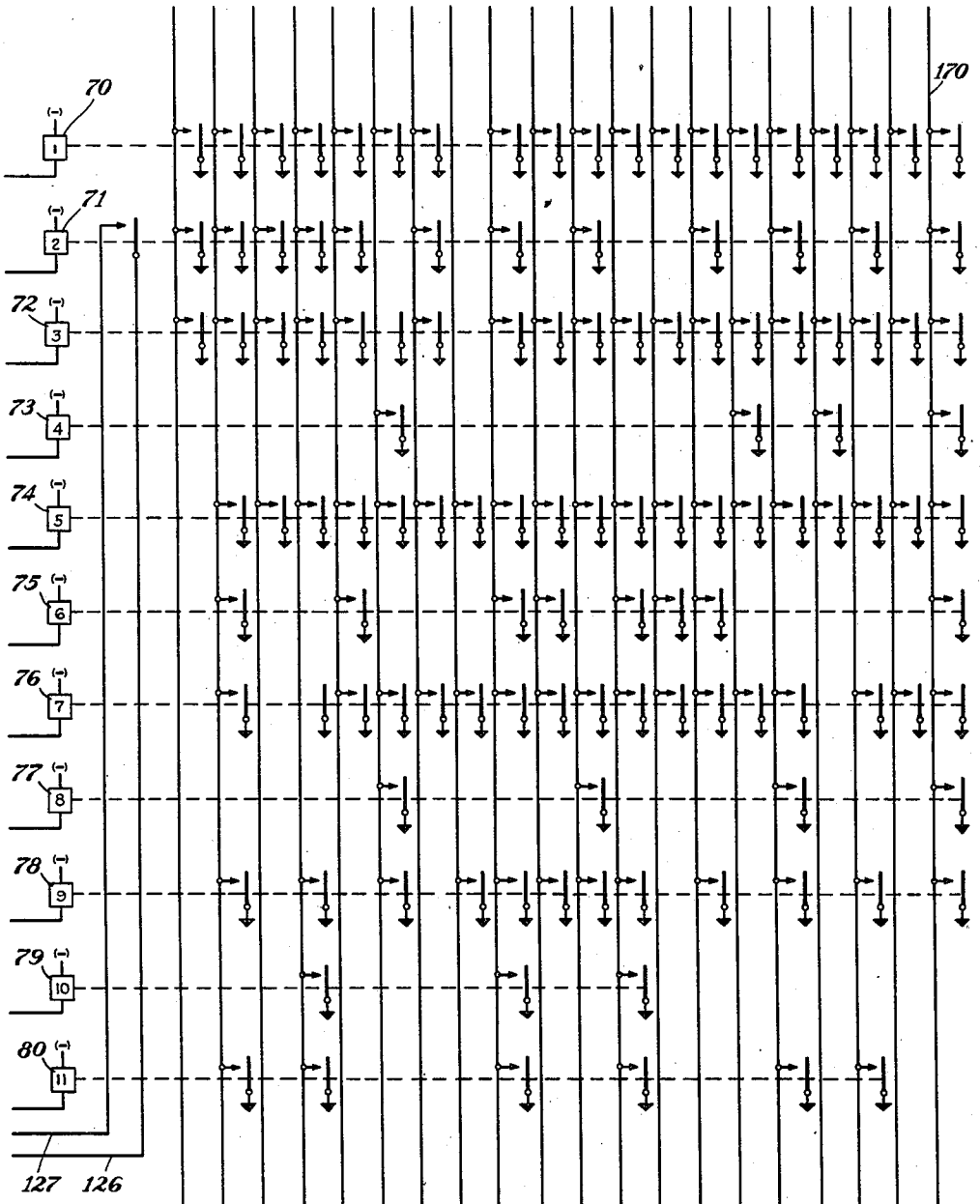


Fig. 3

BY

INVENTOR.
WINFRED T. POWELL

ATTORNEY.

June 1, 1943. W. T. POWELL 2,320,885

SIGNALING SYSTEM

Filed March 21, 1941 4 Sheets-Sheet 4

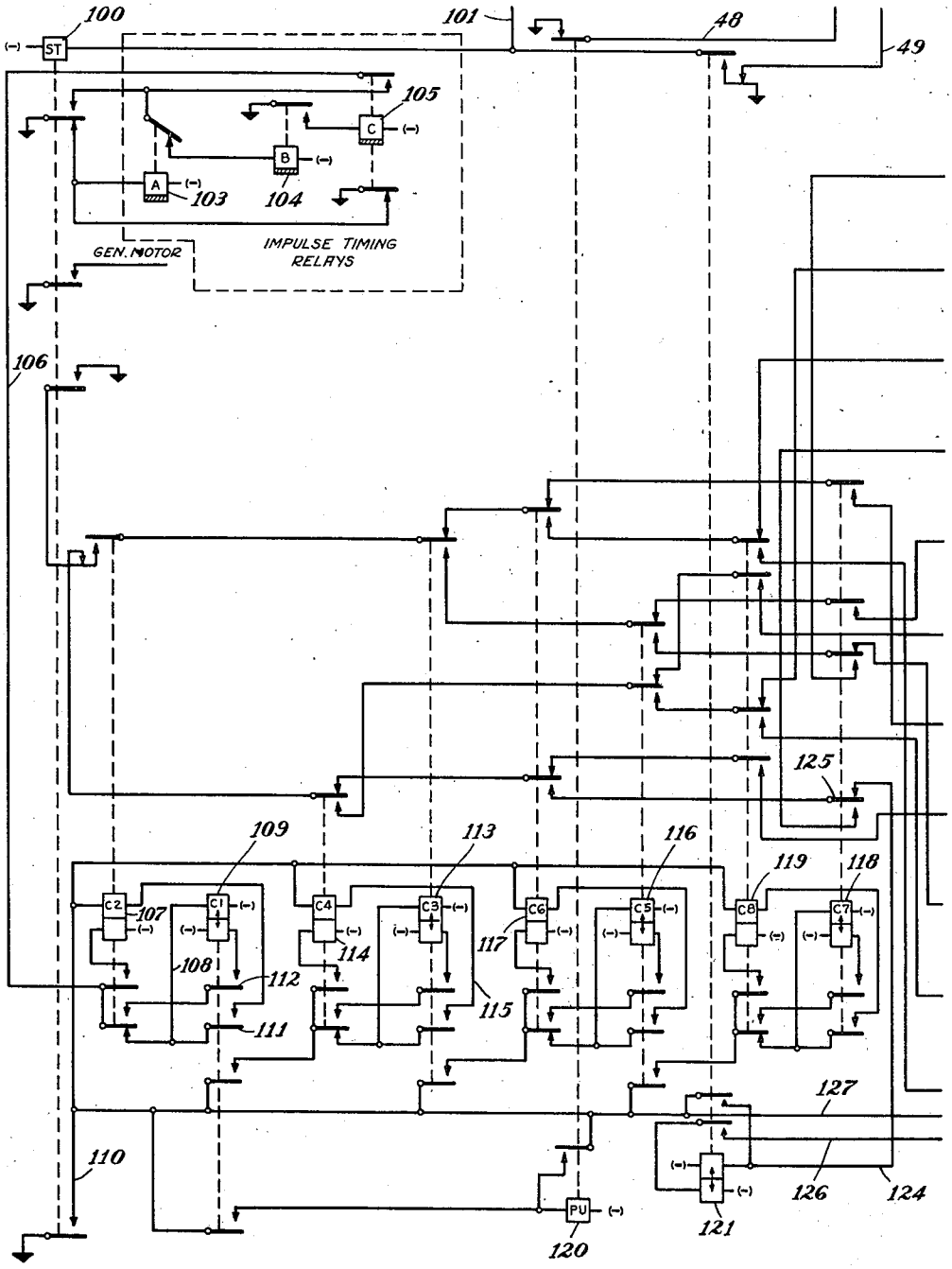


Fig. 4

INVENTOR.
WINFRED T. POWELL

BY

ATTORNEY.

Patented June 1, 1943

2,320,885

UNITED STATES PATENT OFFICE

2,320,885

SIGNALING SYSTEM

Winfred T. Powell, Rochester, N. Y., assignor to The Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y., a corporation of New York

Application March 21, 1941, Serial No. 384,517

5 Claims. (Cl. 179—17)

This invention relates to telephone systems and more particularly to signaling arrangements for use in such systems.

In automatic telephone systems, intended for use in rural communities, it is economical to employ code ringing for multi-party lines as distinguished from selective ringing desired parties on such lines. When such code ringing is employed in an automatic telephone system of the relay selector type, it is preferred to employ a relay type interrupter rather than a mechanical interrupter including a rotating shaft. In such code ringing arrangements it is essential that means be provided so that intended code calls cannot be mutilated and thus originate false signals. Such mutilation of the code call might be caused by effectively connecting the interrupter to the called line in the middle of a code cycle or by permitting the called subscriber to trip the ringing before a code cycle has been completed.

The present invention, therefore, has for its purpose a novel relay arrangement for generating code signals and the provision of a novel arrangement for preventing the code signals generated thereby from being mutilated.

For a more complete understanding of the invention, reference is made to the following description and claims when taken with the drawings which diagrammatically represent a portion of a telephone system including this invention.

Figures 1 and 2, when arranged side by side, represent a calling subscriber's line, a link circuit, and a called multi-station line.

Figures 3 and 4 when placed side by side, below Figures 1 and 2, illustrate the manner in which the relay code interrupter of the present invention cooperates with a link circuit and the counting relays thereof.

It is believed that the invention will best be understood by describing certain of the operations involved in code signaling a wanted subscriber on a called telephone line. When the calling subscriber at substation A originates a call, his telephone line is connected by suitable switching means including contacts 6, 7 and 8, to an idle link circuit LK. The apparatus for interconnecting the calling line and the link circuit as well as the detailed circuit arrangement of the link may be substantially the same as that described in applicant's copending application, Serial No. 356,623 filed Sept. 13, 1940, except for certain differences which will be hereinafter described.

As soon as the calling telephone line is connected to the link circuit through the switching contacts 6, 7 and 8, the impulse relay 10 is energized in an obvious circuit including the two sides of the calling line in series. When the relay 10 is thus energized, it closes an energizing circuit for the slow releasing relay 11 from the negative pole of battery, winding of this relay, front contact and armature of the relay 10 to ground. Relay 11 in turn closes a circuit for operating the slow releasing relay 12 from the negative pole of battery, winding of this relay, lower armature and front contact of relay 11 to ground. Furthermore, relay 11, at its armature 14 and front contact, extends the test conductor 15 of the link through the continuity spring and back contact of relay 16 to ground. The ground potential on the test conductor 15 renders this link circuit unselectable by other calling lines at this time.

The link circuit LK is now in readiness to receive selective impulses which operate a connector (not shown) to connect this link to the wanted multi-party line such as B. The calling subscriber at substation A, operates his dial impulse sender to send a series of impulses corresponding to each digit as well as one or more series of impulses corresponding to the party designation of the wanted subscriber's number. In response to each of the impulses of a series, as is fully described in the mentioned copending application, the impulse relay 10 retracts its armature and thus completes an impulse circuit from ground through the armature and back contact of relay 10, armature and front contact of relay 11, armature and back contact of relay 17, armature and back contact of the busy test relay 18, and thence to certain control relays (not shown) which govern the selective operation of counting relays 19 to 28 inclusive. In response to each series of impulses repeated over this circuit, some one of these counting relays is energized to control a stage in the operation of the relay selection (not shown).

At the conclusion of the units series of impulses, the link LK is thus extended to the terminals of the wanted telephone line. The test of the wanted line is now made and if it is found idle, there will be an absence of ground potential on its test terminal 41. Therefore, the circuit including the test conductor of the link will be open and the busy test relay 18 will not be operated. Immediately following the testing of the wanted line, the relay 30 is operated in a manner similar to that of the relay 93 illustrated in the mentioned application. Relay 30 at its uppermost armature 31 and back contact opens the test circuit of the busy test relay 18.

Following the sending of the units digit im-

pulses, the calling subcriber operates his dial sender to transmit one or two series of impulses corresponding to the one or two digits, as the case may be, in the designation of the wanted station on the selected telephone line. In response to these impulses, some one of the counting relays 19 to 28 is operated. In case the wanted station has a two-digit designation the first digit will be #8 to operate the #8 counting relay 26. Thereupon, impulses, which may be one to ten in number, corresponding to the last digit of the party designation, are transmitted to operate some one of the counting relays. As soon as the #8 counting relay is operated in the course of dialling a two-digit designation, it will effect the operation of the relay 32 (Figure 1) for a purpose to be described.

At the start of the stations digit or digits, the conductor 43 will be grounded. Relay 44 will then be energized from negative battery, resistance, winding of relay 44, its continuity spring and back contact and thence over conductor 43 to ground. Relay 44 when energized in this circuit, closes at its upper front contact, a locking circuit for itself over the holding conductor 45 to ground at the armature and front contact of the relay 12. At the close of the station's digit or digits, the conductor 52 will be grounded. This will complete a circuit for relay 17, from negative battery lower winding of this relay, armature 54 and back contact of relay 53 to ground over conductor 52. With relays 44 and 17 operated, a circuit is closed for energizing the cut-in relay 46 from negative battery, winding of this relay, its continuity spring and back contact, armature 47 and front contact of relay 17, armature and front contact of relay 44, conductor 48 to ground at the back contact and armature of pick-up relay 120. The cut-in relay, when thus energized, closes a locking circuit for itself through its inner front contact and armature, conductor 49, back contact and continuity spring of the relay 121, to ground. Cut-in relay 46 at its armature 50 and front contact, closes a circuit from ground over conductor 101, winding of the start relay 100 to negative battery. The start relay, when operated, initiates the operation of the code impulse interrupter.

In the code ringing arrangement of the present invention, the ringing relay 33 is operated and released, according to any one of a large number of predetermined codes, to complete and to interrupt acocrdingly, a circuit for signaling the stations on the called line. Each time that the ringing relay 33 is energized, signaling current is applied from a ringing generator (not shown) through conductor 34, front contact and armature of ringing relay 33, front contact and armature of relay 17, thence, through the lower link conductor and the lower side of the wanted line through the ringers at the substations on the wanted line and thence over the upper side of the calling line and the link, armature and front contact of relay 17, armature and front contact of relay 33, conductor 35 to the generator ground.

In accordance with the present invention, provision is made for applying ringing current over the circuit, just described, in twenty different combinations of long and short impulses. For example, code #1 might be one long ring, code #2 might be one long ring followed by a short ring and so forth. In order to provide the twenty different code impulses, there are provided eleven so-called "channel" relays 70 to 80 inclusive which, in various combinations, connect ground to the twenty signaling channel conductors extending vertically from the top of Figure 3. Some one of these channels is selectively connected through one of the counting relays 19 to 28 inclusive, to complete the operating circuit of the ringing relay 33. It has been mentioned that if the calling subscriber dials the numeral #8 as a first digit in selecting the ringing code, the relay 32 will be energized in a circuit (not shown) but completed at the armature and front contact of the #8 counting relay 26. Relay 32, when energized, closes a locking circuit for itself through its front contact and armature and over holding conductor 45 to ground at the armature and front contact of relay 12. With the relay 32 energized, the conductors 38 and 39 will be potentially effective instead of conductors 36 and 37 as part of a possible circuit for energizing the ringing relay 33 under the control of one of the channel relays. Thus, by the use of relay 32, eleven channel relays are sufficient for selectively controlling twenty different channels.

In the present arrangement, it is necessary to energize and deenergize the eleven channel relays in succession. In order to effect this result, there are provided three cycling impulse relays 103, 104 and 105 which generate impulses in a circuit including conductor 106 to operate the code counting relays C1 to C8 inclusive in proper combinations. These relays which are designated 107, 109, 113, 114, 116, 117, 118 and 119, operate in pairs, that is, the relays C1 and C2 operate together and similarly the relays C3 and C4 etc. It will be noted in the course of this description that the relay C1 operates in response to each impulse, the relay C3 operates in response to each group of two impulses from the cycling relays, while the relay C5 operates in response to each group of four impulses, from the cycling relays, whereas the relay C7 operates once in response to each group of eight impulses generated by the cycling relays.

As soon as the cut-in relay 46 is energized, as previously described, the start relay 100 is energized in a circuit, completed from the negative pole of battery, winding of the relay 100, conductor 101, front contact and armature of the cut-in relay to ground. The start relay 100 is thus energized and at its armature and back contact, it opens one of the energizing circuits for the primary slow releasing relay 103. However, this relay remains operated since its multiple operating circuit is still completed at the back contact and armature of the tertiary slow releasing relay 105, thus, with both the relays 100 to 103 operated, the secondary slow releasing relay 104 is energized in a circuit extending from the negative pole of battery, winding of the relay 104, front contact and armature of relay 103, front contact and armature of relay 100, to ground. The secondary relay 104 is thus energized and at its armature and front contact completes a circuit for energizing the slow releasing tertiary relay 105. The operation of the relay 105 also opens the multiple operating circuit for the relay 103 so that after a short interval, determined by the constants of the relay 103, it deenergizes. The deenergization of the relay 103 likewise effects the deenergization of the secondary relay 104 and in turn the tertiary relay 105. However, as soon as the relay 105 is initially energized, a circuit is closed from ground, armature and front contact of relay 100, front contact and armature of relay 105, conductor 106, lowermost armature and back contact of relay 107,

conductor 108, upper winding of the differentially wound counting relay 109, to the negative pole of battery.

The relay 109 is energized in the circuit just described and, therefore, attracts its armatures. A break point in a primary locking circuit for the relay 109 is thereby closed from the negative pole of battery, upper winding of this relay, conductor 108, armature 111 and front contact of relay 109, upper winding of the relay 107, conductor 110, lower front contact and armature of the start relay 100 to ground. This circuit is ineffective at this time to operate the counting relay 107 since its upper winding is now short-circuited over the conductor 105 to ground, as long as the relay 105 is energized. However, in the course of the cycling operation, the slow releasing relay 105 will deenergize and thereby will remove the mentioned short-circuit about the upper winding of the relay 107. At this time the relay 107 will be energized and the relay 109 will remain operated in the primary locking circuit. When the tertiary slow releasing relay 105 is again energized in the course of the next cycle, then the lower winding of the relay 109 is energized from the negative pole of battery, lower winding of this relay, its front contact and armature 112, front contact and armature of relay 107, conductor 106, armature and front contact of relay 105, front contact and armature of relay 100 to ground. Since the relay 109 is differently wound and since both its upper winding and its lower winding are now energized, this relay will release its armatures.

The relay 107 is now held operated in a circuit from the negative pole of battery, lower winding of this relay, lower front contact and armature, conductor 106, armature and front contact of relay 105, front contact and armature of relay 100 to ground. Relay 107 is thus maintained operated during the time that the slow releasing relay 105 is operated.

As soon as the first counting relay 109 is operated, a circuit is completed for the C3 counting relay 113. This circuit extends from negative battery, upper winding of the relay 113, lower armature and back contact of relay 114, front contact and armature of relay 109, conductor 119, front contact and armature of relay 100 to ground. The cycle of operation of the relays 113 and 114 is similar to that of the relays 109 and 107. Thus, when relay 113 is energized, it completes a circuit from negative battery, the upper winding of this relay, its middle armature and front contact, conductor 115, upper winding of relay 114 and thence over conductor 110 to ground at the front contact and armature of relay 100. This circuit, however, is ineffective at this time since the upper winding of the relay 114 is short circuited by a branch circuit extending through the back contact and armature of relay 114, front contact and armature of relay 109, conductor 119, front contact and armature of relay 100 to ground. However, when the relay 109 deenergizes at the conclusion of an impulse over the conductor 106, the ineffective circuit just described will function to energize the relay 114 and to hold the relay 113 operated. When the relay 109 is operated in response to the next impulse over the conductor 106, the relay 114 will still be energized in a circuit from ground through the lower winding of this relay, its inner front contact and armature, front contact and armature of relay 109, conductor 110 to ground at the front contact and armature of relay 100. Also, at this time, the lower winding of the relay 113 is energized from the negative pole of battery, winding of this relay its front contact and armature, front contact and armature of relay 114 and thence in multiple with the circuit just described for the lower winding of the relay 114. Since relay 113 is differently wound and since both of its windings are energized, it will release its armatures. However, the relay 113 functions in a manner similar to that just described for the relay 109 to effect the operation of the C5 counting relay 116 which will cooperate with the C6 counting relay 117 in the same manner as relays 113 and 114. Likewise, when the relay 116 operates, it effects the energization of the C7 counting relay 118 and this relay cooperates with a C8 counting relay 119 under the control of the relay 116 in the same manner as relays 116 and 117.

It should be mentioned that the pick-up relay 120 is energized on the first operation of the relay 109, its circuit being completed from negative battery, winding of the relay 120, lower front contact and armature of relay 109, conductor 110, to ground at a front contact and armature of relay 100. Pick-up relay 120, when operated, closes a locking circuit for itself through its inner front contact and armature, conductor 110 to ground. Thus, the relay 120 will be maintained energized as long as the relay 100 is operated. The pick-up relay 120, when operated, opens at its uppermost armature and back contact, a break point in the initial operating circuit of the cut-in relay 46. Thus, no link circuit can seize the code interrupter means until it has completed a cycle and is ready to start another cycle.

It should be stated that in the course of each cycle, the interrupter means generates eighteen impulses. In response to eleven of these impulses, the channel relays 70 to 80 inclusive are energized and deenergized in succession. In response to the next five impulses following the first eleven, none of the channel relays will be operated and this will afford a long silent interval of greater duration than the short silent interval between code signals. This long silent interval will indicate to a listener, the conclusion of the ringing code. In response to the last two impulses, that is, impulses #17 and #18, the channel relay 70 will again be operated and released and channel relay 73 will be operated and released.

It will be noted that the upper winding of the relay 121 was energized at the beginning of the #12 impulse, in a circuit extending from negative battery, winding of this relay, conductor 124, back contact and armature 125 of relay 118, front contact and armature of relay 117, back contact and armature of relay 114, back contact and continuity spring of relay 107, armature and front contact of relay 100, to ground. When the relay 71 is again energized, at the conclusion of the series of eighteen impulses, the lower winding of the relay 121 is again energized from the negative pole of battery, armature and front contact of relay 121, conductor 126, inner armature and front contact of relay 71, conductor 127 thence over conductor 110 to ground, front contact and armature of the start relay 100. Since the relay 121 is differentially wound and since both of its windings are now energized, it will release its armatures. At the uppermost armature and front contact of relay 121, the holding circuit of the start relay 100 is interrupted. At the lowermost armature and front contact of relay 100, the holding circuit for the pick-up relay 120 and any of the operated chain counting relays will be interrupted so that these relays re-

lease. When the relay 120 releases, it applies ground at its back contact and armature to the conductor 48 so that the cut-in relay 46 of a link can be operated to associate the code interrupting means with that link. Also when the relay 121 deenergizes, it reapplies ground at its back contact and continuity spring to the conductor 49.

Let it be assumed that the designation of the wanted station on the called party line is #80. Therefore, in response to the digit #8, the #8 counting relay 26 will be operated. This will result in the operation of the relay 32 (upper right-hand corner figure 1) which is effective to reverse the conditions of the conductors 36, 37, 38 and 39. At the conclusion of this series of impulses, the counting relay 26 will be deenergized. The calling subscriber now dials the digit #0 corresponding to the last stations digit. In response to this series of impulses, the #0 counting relay 28 is operated.

When now the interrupter operates the channel relays as previously described the channel conductor 170 will be successively grounded at the outermost armatures and front contacts of the channel relays #1 to #9 inclusive. This will be effective to transmit a long impulse over conductor 170, the remainder of the circuit being completed at the inner front contact and armature of the counting relay 28, conductor 38, front contact and armature of relay 32, armature and front contact of the cut-in relay 46, winding of the ringing relay 33. Ringing relay 33, when thus operated, will close the ringing circuit from the generator (not shown) through the two sides of the link and of the called line and through the substation ringers thereon.

When the wanted subscriber, that is, at station #80, responds at the conclusion of the ringing code by removing his receiver from its switch hook, the battery feed relay 60 is energized from ground and negative battery through its two windings in series, armatures and back contacts of the ringing relay 33, armatures and front contacts of the relay 17 and thence in series through the remainder of the link circuit and the called line. When the relay 60 is thus operated, it attracts its armatures and at its lowermost armature, short-circuits the relay 44. This short-circuit may be traced from negative battery, resistance, lower front contact and armature of relay 44, armature and front contact of relay 60, back contact and armature of cut-in relay 46 (now deenergized at the conclusion of the code) conductor 45 to ground at the armature and front contact of relay 12. Since relay 46 cannot be released until conductor 49 is deenergized at the end of the code cycle, the operation of relay 60 (if a receiver is removed) during the code cycle will not complete this short-circuit for relay 44 during the cycle.

In the event that the called telephone line was busy at the time it was tested, the busy test relay 18 will be energized from negative battery winding of this relay, back contact and armature of relay 30 and thence over the test conductor to ground, on the test terminal of the busy wanted line. Busy test relay 18, when operated, closes a locking circuit for itself through its winding, its inner front contact and armature and thence over holding conductor 45 to ground at the armature and front contact of relay 12. Busy test relay 18 at its uppermost armature and back contact, also interrupts the original impulse repeating circuit for the control relays of the counting relay chain. With the busy test relay 18 energized, a busy tone from a source (not shown) will be transmitted to the substation A of the calling subscriber.

In the event that the wanted subscriber's station is on the same line as the calling subscriber's station, in other words, a reverting call, the calling subscriber will be instructed to dial the code series of impulses corresponding to the wanted station in spite of the fact that the busy signal is being received. This subscriber is also instructed after dialling such series of code impulses to hang up his receiver for an interval sufficient to permit the called party to be signaled and to answer. In the case of such a revertive call, after the busy test relay has been operated in the manner described, the revertive busy test relay 53 will be operated from negative battery, winding of relay 53, conductor 61, front contact and armature of relay 18, back contact and continuity spring of relay 30, conductor 45, armature and front contact of relay 12 to ground. The revertive busy test relay, on operation, closes a locking circuit for itself from negative battery through its winding, lower back contact and armature of relay 16, armature and front contact of relay 53, armature and front contact of relay 30 and thence to ground over the holding conductor 45. The revertive busy test relay 53 at its uppermost armature 63 and front contact closes a break point in a substitute impulse repeating circuit for operating the relays which control the group of counting relays. This circuit is traceable from ground, armature and back contact of impulse relay 10, armature and front contact of slow releasing relay 11, armature and back contact of relay 17, armature and front contact of busy test relay 18, armature and front contact of relay 53, armature and back contact of relay 44 and thence over the remainder of the original impulse repeating circuit to the control relays (not shown). Thus, the stations series of code impulses can be repeated to operate the counting relays in the manner already described. With the revertive busy test relay 53 energized, the circuit which maintained the relay 16 operated from the time that the link was seized is interrupted. This circuit is traceable from negative battery, lower winding of this relay, back contact and armature of relay 53, armature and front contact of relay 12 to ground. Since this operating circuit is interrupted and since the upper winding of the relay 16 is short-circuited, as will presently be described, the relay 16 deenergizes to complete the above mentioned locking circuit for relay 53. This short-circuit extends from ground, front contact and armature of relay 12, armature and front contact of relay 53, test terminal of the called line through the test conductor 64 of the link and thence to the test terminal of the calling line (since they are the same) conductor 15, front contact and armature 14 of relay 11, continuity spring and front contact of relay 16 to the right hand terminal of the upper winding of relay 16. Since ground is also connected to the left hand terminal of the upper winding of relay 16, this relay releases.

When the calling subscriber temporarily replaces his receiver on its switch in accordance with instructions to be followed in the case of a revertive call, then, of course, the impulse relay 10 deenergizes. Shortly thereafter, the slow releasing relay 11 releases and at its lowermost armature and front contact interrupts a circuit

which has been maintaining operated the slow releasing relay 12. The relay 12 is now maintained energized from negative battery, winding of this relay, armature and back contact of relay 11, back contact and continuity spring of relay 60, upper winding of relay 17, front contact and armature of revertive busy test relay 53, conductor 45, armature and front contact of relay 12 to ground. Relay 12 is maintained operated in this circuit and the relay 17 is operated. The relay 17 at its armature 47 and front contact closes a break point in the initial operating circuit of relay 46 so that the code interrupter can be seized and operated in the manner already described. The code interrupter will transmit a code of ringing impulses to signal the wanted subscriber as previously described. When the called subscriber answers, the relay 60 is operated and at its lowermost armature and front contact, short-circuits the relay 44 in the manner set forth in connection with a non-revertive call.

It is unnecessary to describe the manner of supplying talking battery to the calling and called telephone lines or to describe the manner in which a connection is released since this is all in accordance with the well-known practice.

What I claim is:

1. In a telephone system, a plurality of telephone lines, certain of which are multi-station lines, selectively actuated means including a series of counting relays for connecting any one of said lines to a wanted multi-station line, a signaling circuit including said wanted multi-station line, means for periodically completing said circuit, said means including a selected one of a plurality of channel conductors, means including a selected one of said counting relays for selecting a desired channel conductor, a series of relays closing predetermined break points in said channel conductors, and means for operating said last-mentioned series of relays in succession in time intervals of predetermined duration.

2. In a telephone system, a plurality of telephone lines, certain of which are multi-station lines, selectively actuated means including a series of counting relays for connecting any one of said lines to a wanted multi-station line, a signaling circuit including said multi-station line, a relay for periodically completing said circuit according to various codes, an operating circuit for said relay including a selected one of a plurality of channel conductors, means including a selected one of said counting relays for selecting a desired channel conductor, a series of relays closing predetermined break points in said channel conductors, and means for operating said last-mentioned series of relays in succession in time intervals of predetermined duration.

3. In a telephone system, a plurality of telephone lines, certain of which are multi-station lines, selectively actuated means including a series of counting relays for connecting any one of said lines to a wanted multi-station line, a signaling circuit including said wanted multi-station line, a relay for periodically completing said circuit according to various codes, an operating circuit for said relay including a selected one of a plurality of channel conductors, means including a selected one of said counting relays for selecting a desired channel conductor, a second series of relays operating in a given cycle to close predetermined break points in said channel conductors, means for operating said second series of relays in succession in time intervals of predetermined duration, said last-mentioned means including a third series of relays operating in sequence in response to impulses, and means for generating said impulses.

4. In a telephone system, a plurality of telephone lines, certain of which are multi-station lines, selectively actuated means including a series of counting relays for connecting any one of said lines to a wanted multi-station line, a signaling circuit including said wanted multi-station line, a relay for periodically completing siad circuit according to various codes, an operating circuit for said relay including a selected one of a plurality of channel conductors, means including a selected one of said counting relays for selecting a desired channel conductor, a second series of relays operating in a given cycle to close predetermined break points in said channel conductors, means for operating said second series of relays in succession in time intervals of predetermined duration, said last-mentioned means including a third series of relays operating in sequence in response to impulses, means for generating said impulses, and means preventing interruption of the cycle of operation of said second series of relays.

5. In a relay chain of the character described, a series of relays cooperating in pairs, one relay of each pair functioning as a primary relay and the other relay of the pair functioning as a secondary relay, each primary relay being differentially wound, an impulse circuit normally including a winding of the first primary relay of the series, means for generating impulses in said circuit in the form of alternate completions and interruptions of said circuit, the first completion of said circuit effecting the energization of one winding of the primary relay of the first pair, an initial operating circuit for the first secondary relay completed on the operation of said primary relay, said last-mentioned circuit being short-circuited until said impulse circuit is interrupted at which time said secondary relay is operated, said secondary relay on operation effecting the energization of the second winding of the primary relay whereupon the primary relay deenergizes so that it is alternately operated in response to one completion of said impulse circuit and released in response to the next completion of said impulse circuit, the cycle of operation of the remaining pairs of relays being the same as that just described, the operation of a primary relay of a given pair being controlled by the primary relay of the next preceding pair of relays in the series.

WINFRED T. POWELL.